Future Naval Capability: CMP 14-02
UAS Interface, Selection, Training Technologies (U-ASISTT):

Development of Control Station Human-Machine Interface (CaSHMI) for Unmanned Systems

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Acknowledgements

Performers

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Progeny Systems

Outline

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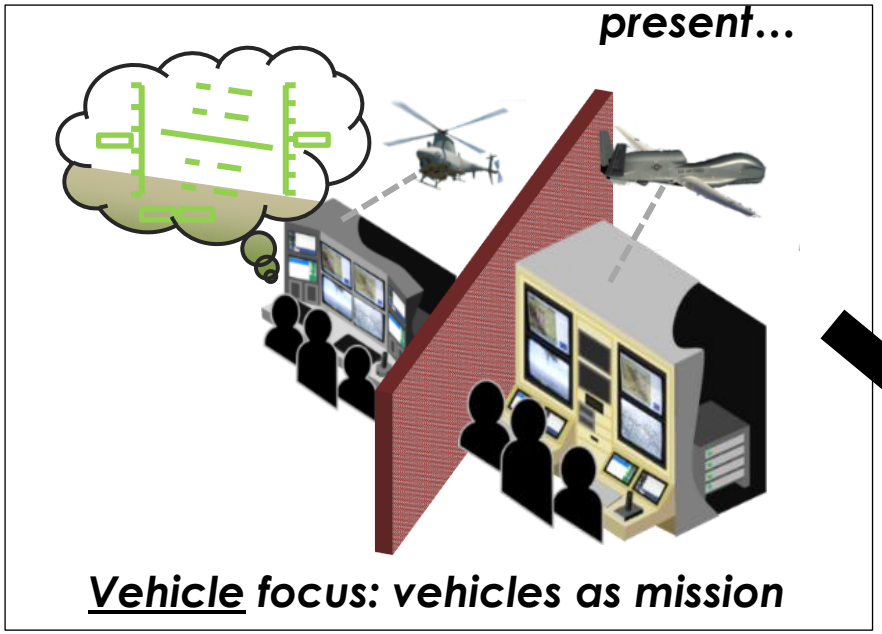
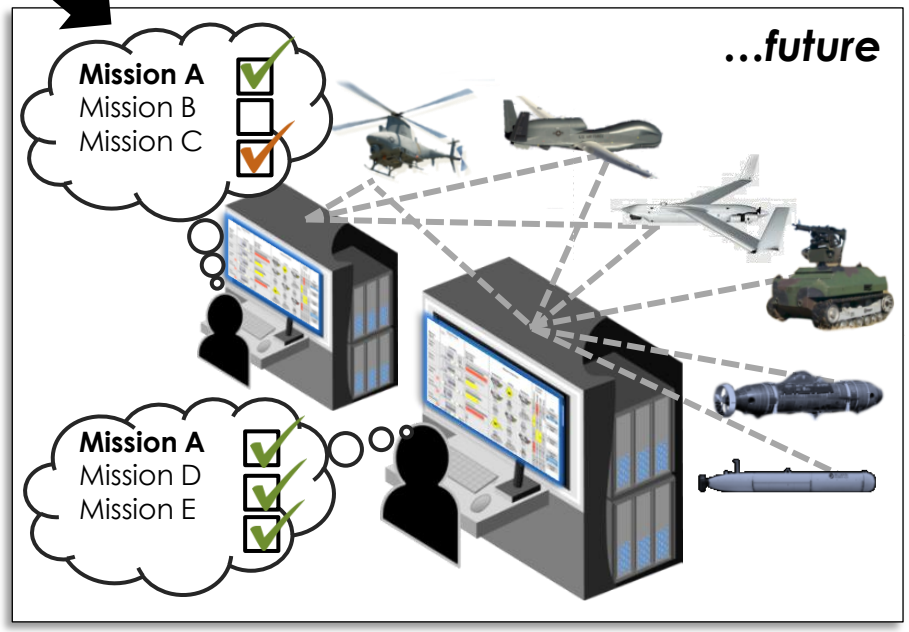
Motivation and Approach

Motivation





Approach

- Concept of employment for UxV supervisory control and mission management
- Human-Machine Interface (HMI) Designed and Developed:
  - With considerable input from Fleet UAS and UUV operators
  - Using formal Human Factors design methodology
- Software implementation for
  - ✓ Command and control for submarine Blackwing UAV[1] & UUV[2,3]
  - Fire Scout experimentation (Summer 2017)
- CaSHMI is transitioning to
  - Submarine's Payload Control System (PMS 425 in PEO SUB) and
  - Common Control System (CCS) (PMA 281 in PEO U&W)

[1] UAV = unmanned air vehicle
[2] UUV = unmanned undersea vehicle
[3] mission toggle for UUV C2

CaSHMI
A Focus on the Human-Machine Interface

CaSHMI Human Machine Interface (HMI) Design Objectives

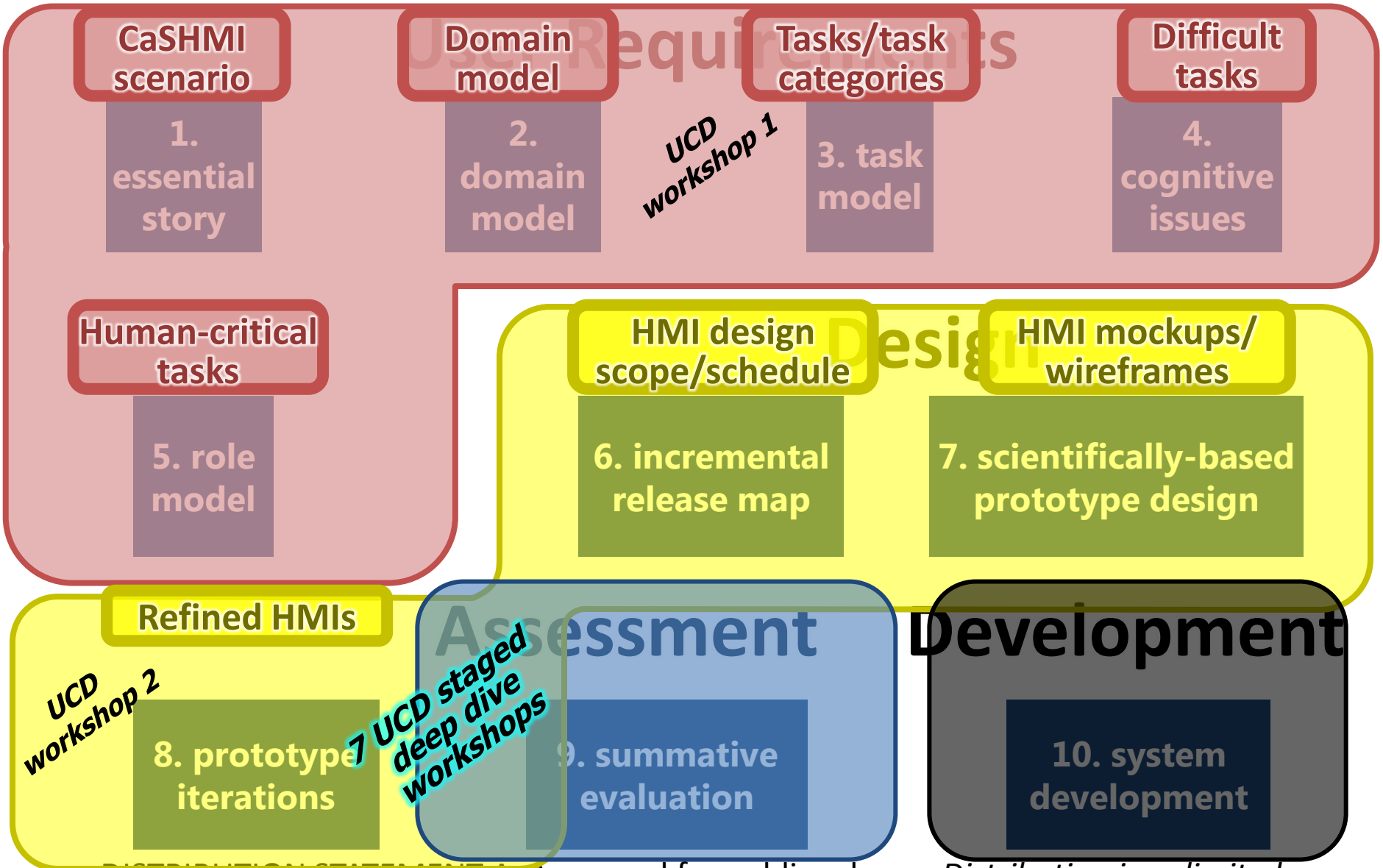
- Develop a HMI design that
  - is **<u>better matched to operator tasks</u>** involved in using unmanned vehicles
    - ➢ Improve operator performance, more efficient use of personnel, achieve benefits offered by unmanned vehicles
  - is **<u>standardized</u>** for use across different unmanned vehicles (UAV, UUV) employed in different domains
    - ➢ Reduce training costs and time
  - can **<u>scale</u>** for *future* types of unmanned vehicles/sensors, operations, automation, and operator roles
    - ➢ Reduce engineering costs of expanding to future vehicles/sensors, etc

Pave the way for future employment of vehicles and sensors

User Centered Design

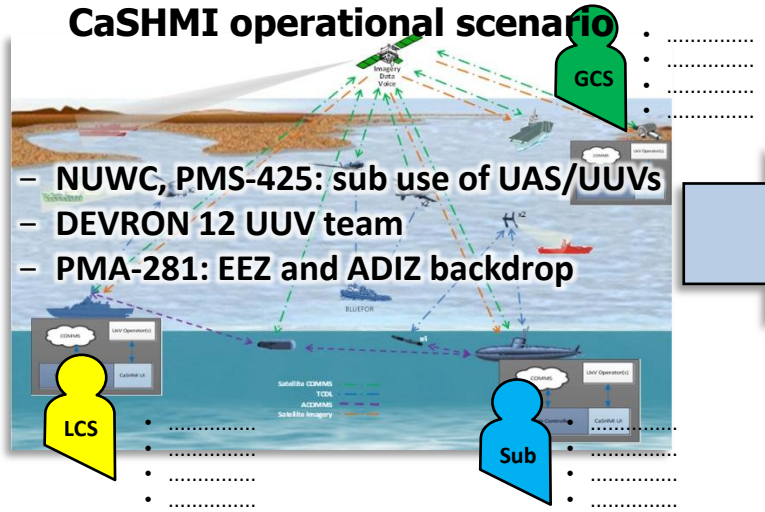
- Employed User Centered Design (UCD) process to ensure that CaSHMI supports operator task and domain needs
  - Requirements, Design, Assessment, Development
  - Continuous user involvement

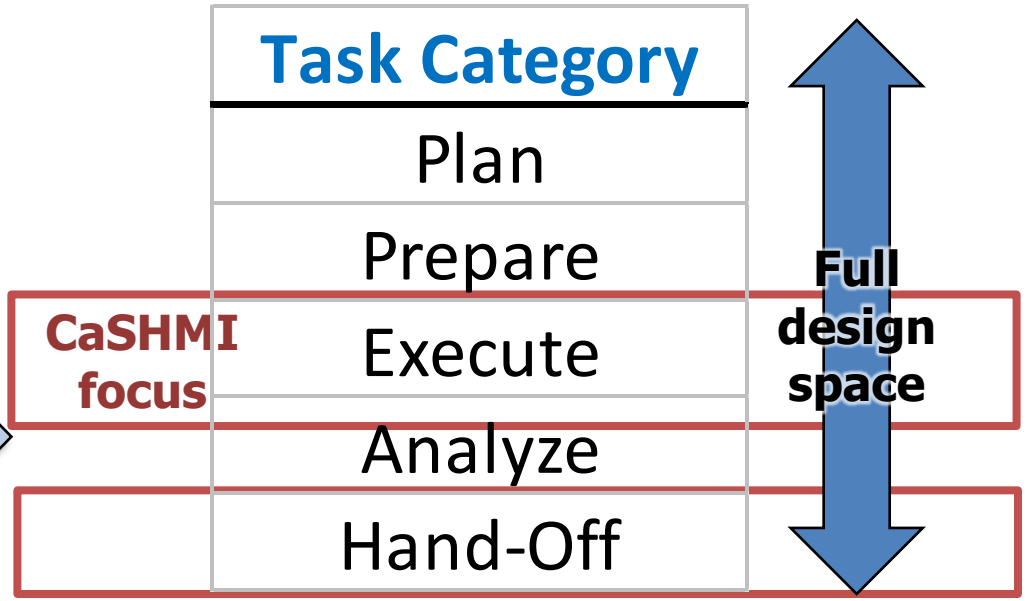
User-Centered Design (UCD) process tailored for CaSHMI



Established task requirements and information needs for UxV operations

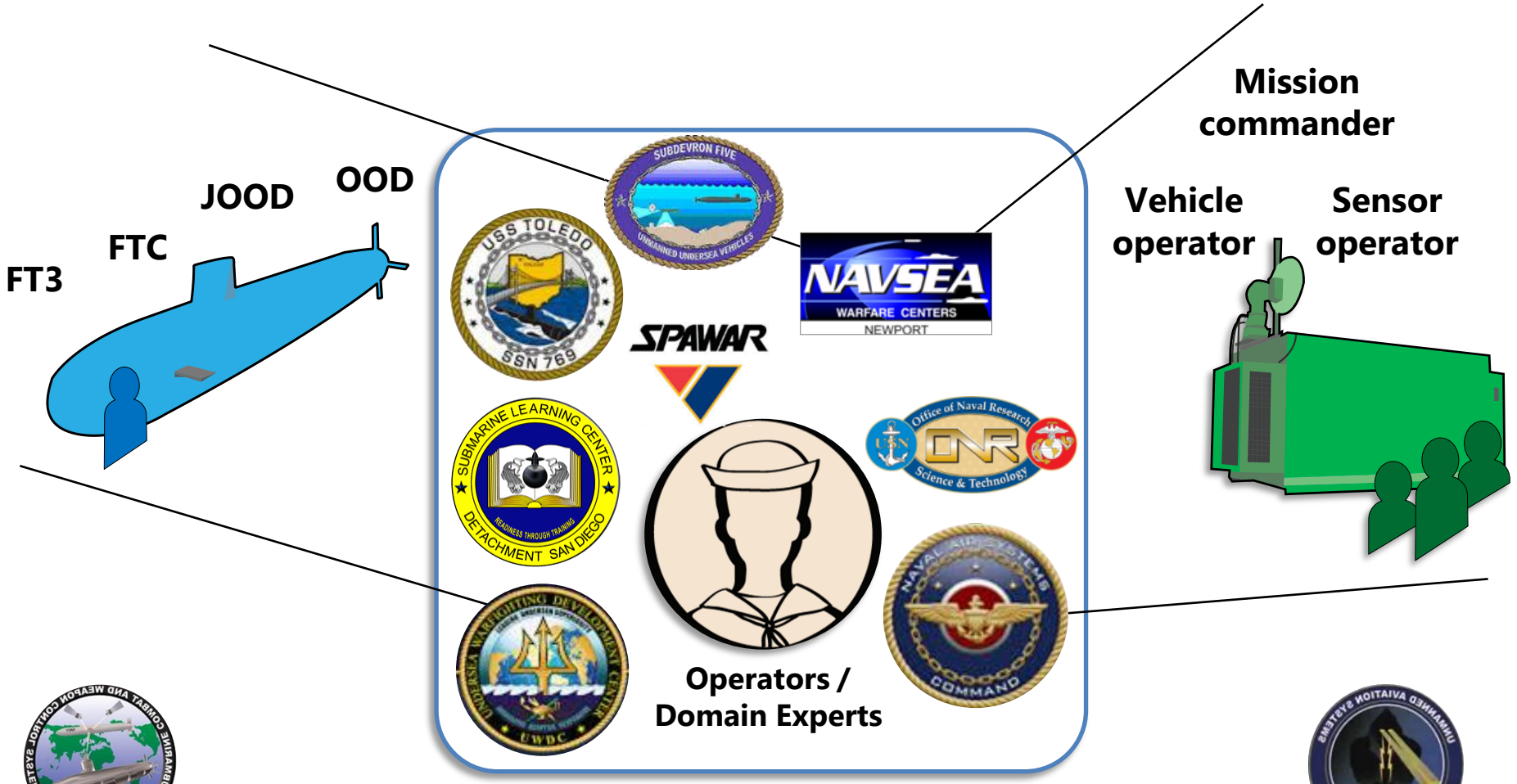
- Identified **common tasks** involved in managing unmanned assets from GCS, LCS, Sub in operational scenario, to specify what tasks CaSHMI must support
- Considered range of
  - unmanned platforms
  - domains
  - operator roles





Task requirements are foundation for CaSHMI HMI design

Continuous operator/Fleet involvement during design



Mix of repeat and new participants across operator workshops and sessions

UCD 1: 8
UCD 2: 8
UCD Deep Dives: 15

Some guiding principles used throughout CaSHMI Build 1 designs...

Information organization and access

- Organize information hierarchically, to facilitate *understanding of relationships*
- Support linking of related information, to facilitate *information integration*
- Facilitate comparison and prioritization, for *supervisory management*
- Carefully map salience to severity/concern, to effectively *manage attention*
- Facilitate access to task-relevant information (availability in display ≠ accessibility by operator!)
- Represent trend and projection, to facilitate *proactivity and prioritization*

Consistency with operator's mental model and existing work environment

- Exploit familiar metaphors and intuitive coding, to *reduce learning curve and training*
- Maintain consistency with content and coding in existing systems
- Code factors that are common across UxVs, to facilitate *generalizability*

Scalability

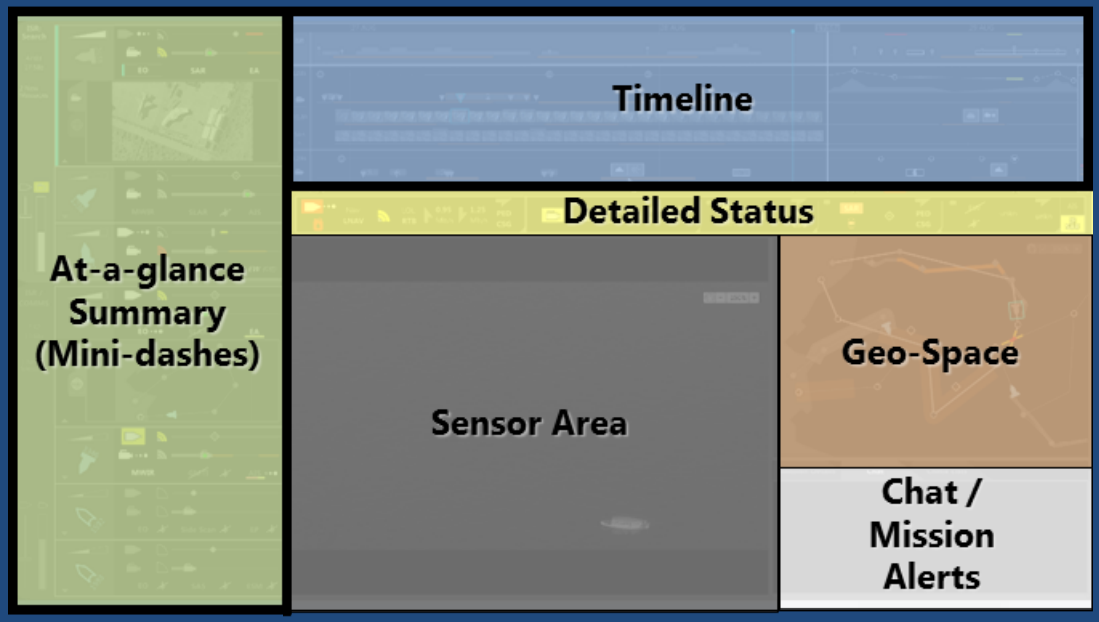
- Use scalable techniques for content that is likely to increase in number
- Develop concepts that work with expected future automation and nearer-term "manual" processing and populating

Multi-UxV management is fundamentally an *information management* challenge.
***Abstraction* is the overarching design philosophy!**

CaSHMI Layout

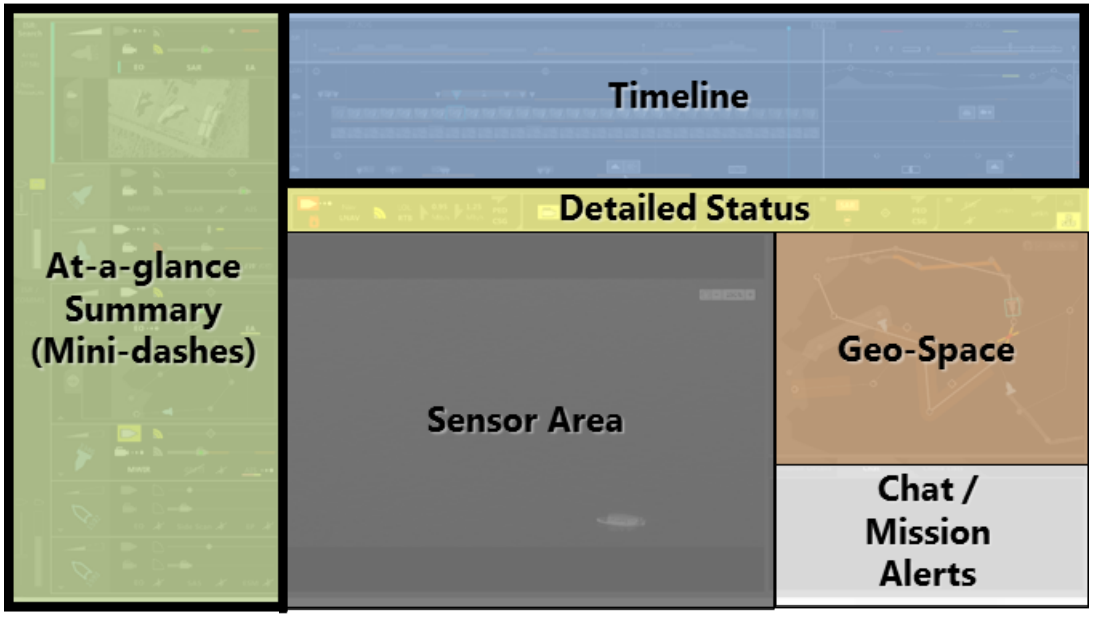
CaSHMI manages information by organizing it into *functional containers*.

- **Information in containers is abstracted for high-level summaries, with progressive drill-down based upon operator selection or driven by critical mission events.**
- **Containers can be moved and optimized for different workstations, users, and/or missions.**



- Intuitive progression from summary to details
- Interchangeable Geo-Space and Sensor Area
- Design fits all containers into a single screen…
  - …alternatives for expanding onto multiple screens
- Possibilities for desktop and mobile configurations

Overview and benefits of CaSHMI



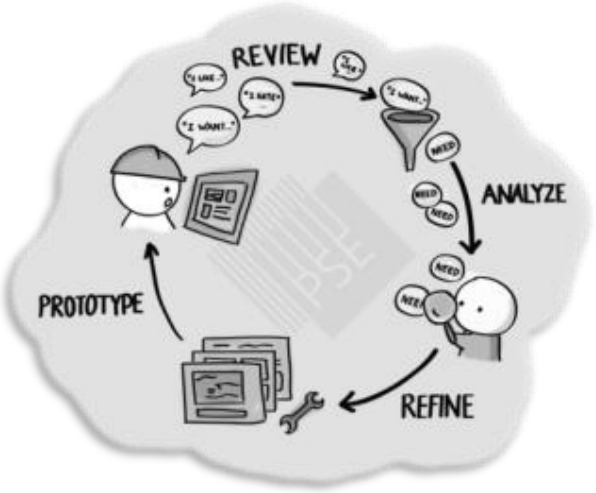
What's new and improved in CaSHMI:

- Most **important** and frequently needed information is **easiest to access**
- Operators can **maintain awareness** of important status for non-selected unmanned vehicles **without moving away** from their primary vehicle of focus (supervisory control)
- **Consistent** with existing contact mgmt HMIs (color, contact symbology)
- Single design **accommodates different** unmanned vehicles (current and future, UAV/UUV), manages information increase for operator from future proliferation of UxVs in battlespace
- Supports **future operational concepts** of vehicle/sensor handoff/handover, inorganic sensors

CaSHMI Assessment & Testing

Using qualitative and quantitative methods to validate and refine design

- Ongoing formative assessments to validate and refine design
  - **Qualitative**:
    - Structured walkthroughs with operators/domain experts (workshops and telecons)
    - Live asset demonstrations
  - **Quantitative**:
    - Estimates of task execution steps, time, underlying processes
    - Laboratory experimentation



Quantitative modeling applied: CaSHMI vs. Alternatives

Modeling* comparison of task execution with CaSHMI versus other technologies

- Number and types of tasks
- Quantitative time estimates

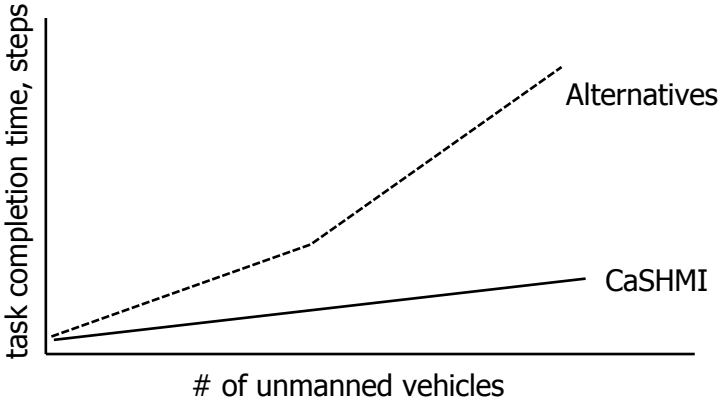
- **Example** results
  - CaSHMI offers improvements
    - Adjusting vehicle controls (i.e., altitude and speed)
    - Monitoring vehicle routes
  - CaSHMI meets existing capability
    - Adjusting loiter parameters

Task Category
Plan
Prepare
Execute
Analyze
Hand-Off

CaSHMI focus

- Can highlight pain points and points with potential for error (e.g., potential for misses)
- Can examine impact of increasing # of UxVs on task performance (scalability)

Illustrative example of quantitative output…



*Model Human Processor (Card, 1981)

NAVSEA WARFARE CENTERS NEWPORT

2016 Annual Naval Technology Exercise (ANTX)

Submarine Combat System C2 of Cross Domain UxV Demonstration

AN/BYG-1 Combat System

JAUS DDL

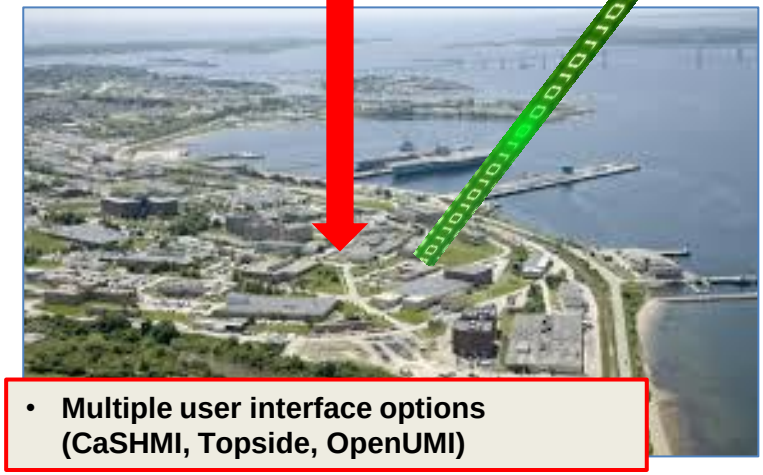
Blackwing UAV

UAV and UUV re-tasking

UAV and UUV position and status updates

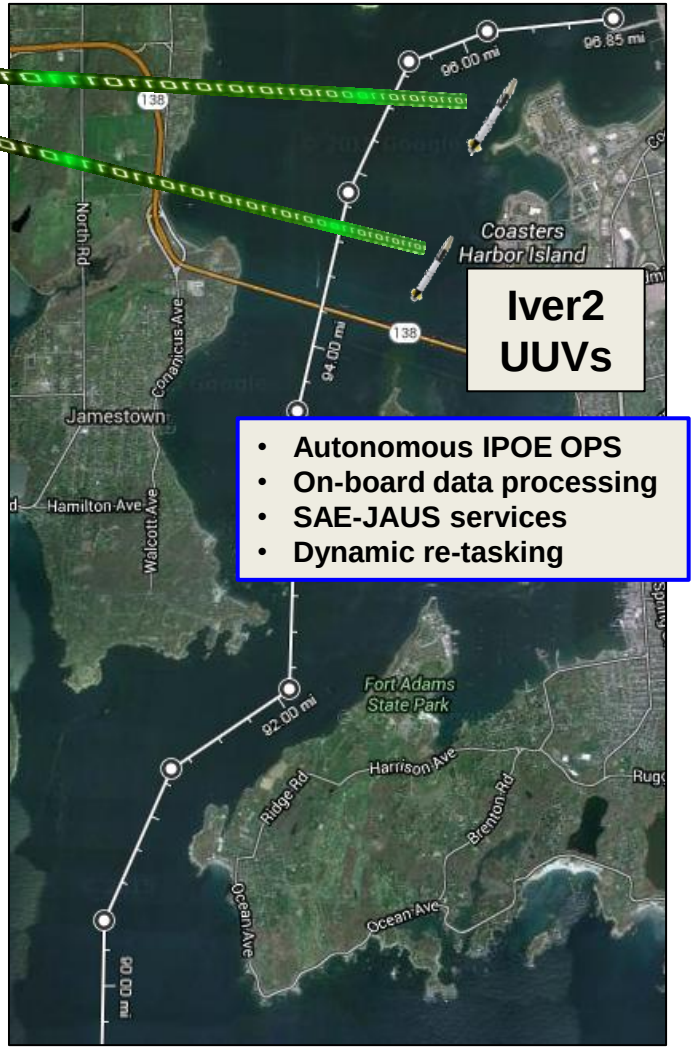
IPOE data exfiltration

Surface contact observations



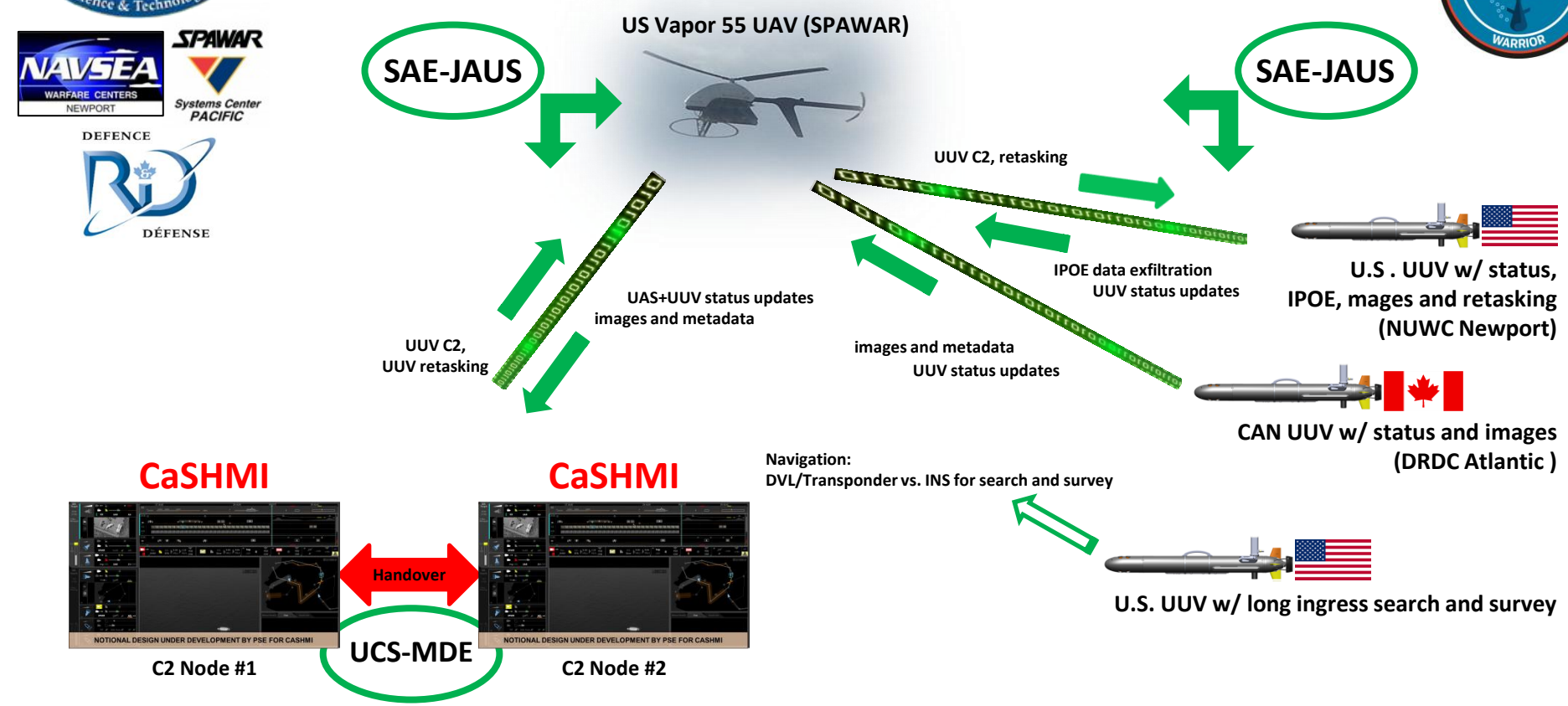
- **Multiple user interface options (CaSHMI, Topside, OpenUMI)**

Bi-directional C2 of UxVs from SCS using SAE-JAUS via DDL Radio Link



- **Autonomous IPOE OPS**
- **On-board data processing**
- **SAE-JAUS services**
- **Dynamic re-tasking**

OV-1: CaSHMI in Unmanned Warrior 2016



CaSHMI accomplishments

1. **C2 node for cross-domain UxV operations**
2. **UxV status, IPOE data display, and imagery**
3. **UUV retasking** (mission toggle) **through UAV relay**
4. **Multi-station (2x) sharing of UxV display (status and data exfil) and locally shared control of UUVs (data queries, retasking of UUVs through UAV relay)**

Summary

- CaSHMI has developed a human-machine interface (HMI) design for mission management of multiple cross-domain Unmanned Vehicles (UxVs) with a minimal number of operators in support of a range of Navy operational missions
- The design supports today's Fleet and provides a roadmap for future HMI development to support
  - Increasing numbers of UxVs and UxV missions
  - Expanded range of both vehicle and interface autonomy
- Unique standards based functionally modular architecture Decouples user interface from vehicle controller and provides numerous benefits including:
  - Vendor independent modifications & expansions of OMI and UxV controller
  - Vehicle agnostic functionally is common across UxVs
- Human Factors Testing
  - Qualitative modeling shows benefits of CaSHMI
- Successful live asset UxV command and control and data exfiltration has been performed with prototype software of relevant portions of the HMI design

CaSHMI is an Enterprise Solution for Cross-Domain Unmanned Systems Control and Management